08.67 Compression test apparatus
08.68 Shear strength test apparatus

Operating instructions

All it takes for environmental research
1 About these operating instructions

❖ If the text follows a mark (as shown on the left), this means that an important instruction follows.

❗ If the text follows a mark (as shown on the left), this means that an important warning follows relating to danger to the user or damage to the apparatus. The user is always responsible for its own personal protection.

Text Italic indicated text indicates that the text concerned appears in writing on the display or must be typed.

1.1 General safety precautions

❖ Read and understand these entire instructions before proceeding.

- This apparatus is for soil research applications and has to be operated by qualified operators only.
- A qualified operator is well trained, mental and physical fit to operate complex multiple instruments.
- Take care for personal hygiene and environmental precautions in case operating contaminated samples.
- The apparatus operates with severe test forces, be sure to follow the safety instructions at all times to prevent injuries.
- Do not operate with damaged cord, wires, hoses or any other parts.
- Do not operate at any voltage or frequency other than 120-240 VAC, 50-60 Hz.
- Disconnect apparatus from electrical and airpressure supply before installation, or servicing.
- Do not expose apparatus to rain, or use in wet locations it is rated for indoor lab locations only.
- Servicing should be performed by QUALIFIED PERSONNEL ONLY!
- Do not operate with removed enclosure panels or disabled safety precautions.
- Only original replacement parts supplied by Eijkelkamp are allowed to service.

❗ Please be aware of the instrument safety precautions to prevent human danger or instrument damage, do not change, manipulate or operate the instrument in any possible harmful way.

❗ In case of problems press the EMERGENCY/STOP button.

The button will be locked and a save situation is secured. To recover turn the button clockwise to unlock and press the yellow button to continue.

❖ Eijkelkamp explicit informs you that product training is highly recommended and this operating instructions are only for indicational purpose.

❖ The instructions and specifications can be changed without notice and no rights whatever can be claimed.
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2 Product descriptions

08.67 Compression apparatus for measuring soil compression and simultaneous measuring of soil suction with tensiometer

- Sample diameter 100 mm
- Sample height 30 mm
- Complete instrument inclusive software to configure, calibrate and read-out the instrument
- Simultaneously operation of up to 8 instruments

The ‘Compression test apparatus measures the compression of an undisturbed round soil sample. During the measurement(s) the soil water matrix, compression stress and settlement are measured.

This equipment measures the soil consolidation in accordance to NEN 5118, EN17892-5 and ASTM D698 - 07e1 considering the following restrictions:
- The maximum specimen load is 600 kPa for a 100 mm sample ring
- Tests are conducted in non water immersed condition
- Please consult instrument specification for detailed information in case of accreditation

Global method (steps) of measurement:
- Placement of the soil-sample (ring) into the device
- The soil sample is exposed to a vertical pressure/load. The pressure step(s) depend(s) on the structure of the sample.
- The installation is accommodated with a linear measuring apparatus; tensiometer; load cell; etc.
  - The displacement sensor measures the compaction/compression of the soil sample.
  - The ground-water pressure (soil moisture tension) in the soil sample is measured by a tensiometer.
  - The load cell registers the pressure/load and gives feedback to the DAQ (Data Acquisition Device) device and regulator to control the load accurately.
- During the exposed load, the sample is compressed and all sensors are measured at predefined Log-intervals.
- The test indicates the difference in compression of samples with different soil-densities (saturated/unsaturated soil-samples and disturbed/undisturbed soil-samples).
- The measurement results are stored and presented both numerical and graphical by the software

08.68 Shear strength apparatus for measuring soil shear strength under compression and simultaneous measuring of soil suction with tensiometer

- Sample diameter 100 mm
- Sample height 30 mm
- Complete instrument inclusive software to configure, calibrate and read-out the instrument
- Simultaneously operation of up to 8 instruments

The ‘Shear test apparatus measures the shear stress of an undisturbed round soil sample. During the measurement(s) the soilwatermatrix, compression stress and settlement are measured.

This equipment measures the soil shear stress in accordance to EN17892-10 and ASTM D3080-98 considering the following restrictions:
- The maximum specimen load is 600kPa for a 100mm sample ring
- Tests are conducted in non water immersed condition
- Please consult instrument specification for detailed information in case of accreditation

Global method (steps) of measurement:
- Placement of the soil-sample (ring) into the device (soil sample-holder).
- The soil sample is exposed to a vertical pressure/load. The pressure step(s) depend(s) on the structure of the sample.
- The installation is accommodated with a linear measuring apparatus; tensiometer; load cell; etc.
  - The displacement sensor measures the compaction/compression of the soil sample.
  - The ground-water pressure (soil moisture tension) in the soil sample is measured by a tensiometer.
- The load cell registers the pressure/load and gives feedback to the DAQ (Data Acquisition Device) device and regulator to control the load accurately.
- The shear-displacement has a user defined constant speed

- During the exposed load, the sample is sheared and the shear force is measured at predefined Log-intervals.
- The test indicates the difference in shear force of samples with different soil-densities (saturated/unsaturated soil-samples and disturbed/undisturbed soil-samples).
- The measurement results are stored and presented both numerical and graphical by the software
### 2.1 Technical specifications

<table>
<thead>
<tr>
<th>Item</th>
<th>Range</th>
<th>Resolution</th>
<th>Accuracy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vertical stress</td>
<td>0-600 kPa</td>
<td>0.1 kPa</td>
<td>2 kPa</td>
</tr>
<tr>
<td>Response speed</td>
<td>&lt;10 sec. @1% endvalue (adaptable by PID controller parameters)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Horizontal stress *</td>
<td>0-400 kPa</td>
<td>0.1 kPa</td>
<td>2 kPa</td>
</tr>
<tr>
<td>Shear speed*</td>
<td>0-2 mm/min</td>
<td>0.01 mm/min</td>
<td>0.1 mm/min</td>
</tr>
<tr>
<td>Shear stroke *</td>
<td>20 mm</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Soil moisture</td>
<td>-1000 +1000 hPa</td>
<td>0.1 hPa</td>
<td>2 hPa</td>
</tr>
<tr>
<td>Compression</td>
<td>0-30 mm</td>
<td>0.001 mm</td>
<td>0.1 mm</td>
</tr>
<tr>
<td>Sample log rate</td>
<td>0.1…60 sec.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pressure in max</td>
<td>0.7 Mpa / 7 bar</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Force max</td>
<td>5 kN</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Stress out max</td>
<td>600 kPa</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Adapter input</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mains supply</td>
<td>100-250 Vac</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mains frequency</td>
<td>47-63 Hz</td>
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<td></td>
</tr>
<tr>
<td>Power consumption</td>
<td>0.8 W</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Adapter output</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Supply voltage</td>
<td>30 Vdc</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Max current</td>
<td>1.2 A max</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Environmental conditions</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ambient</td>
<td>For indoor use only</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Temperature</td>
<td>15-35 ºC</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Humidity</td>
<td>20-80% RH (non condensing)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dimensions</td>
<td>55 x 75 x 135 cm</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Weight</td>
<td>08.67 kg</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Weight</td>
<td>08.68 kg</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Software language</td>
<td>English</td>
<td></td>
<td></td>
</tr>
<tr>
<td>PC connection</td>
<td>USB</td>
<td></td>
<td></td>
</tr>
<tr>
<td>PC operating system</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>XP, Vista, Windows7 (administrator rights)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>PC performance</td>
<td>Vista processor system performance rating 5* or higher will operate up to 8 instruments Simultaneously.</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>* Best way to show the spec and what Vista thinks of it is to browse to Control Panel -&gt; System and Maintenance -&gt;Performance Rating and Tools.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
2.2 Schematic construction Compression test apparatus
2.3 Schematic construction Shear test apparatus

- Settlement sensor
- Traverse or crossarm
- Vertical stress sensor
- Sample stamp rod
- Sample stamp
- Shear part sample chamber
- Static part sample chamber
- Vertical stress rods
- Pressure transducer assembly
- Soil sample
- Tensiometer assembly
- Sintered plate
- Table
3 Installation

3.1 Requirements for installation

- Compressed-air: clean, stable (without drops/impact), dry air must be available in the operating range of 6-7 bar. Pressure regulator can be exposed to a maximum operating pressure of 1 MPa = 10 bar (set-pressure= 0.05-0.85 MPa).
- Connection plug and tube clamp to connect the delivered compressed-air tube (D=14x8 mm) to your compressor system.
- Mains supply near instrument: for connection of the adapter (Shear Strength Test Apparatus) and the connection of the PC/laptop.
- Up to date PC/laptop; a clean system with only the operating software and probably office software. PC operating systems: XP, Vista, Windows7 (administrator rights).
  PC performance Vista processor system performance rating 5* or higher will operate up to 8 instruments simultaneously.
  View the rate in Vista: browse to Control Panel -> System and Maintenance -> Performance Rating and Tools. Optional virus protection and internet access are preferred.
- Water, distilled or deionised, well degassed (-950 hPa); and the equipment to make this.
- Sample-rings d 103x100 h 30 mm).

3.2 Environment

Make sure that you place the apparatus in a clean, dry and non direct sunlight surrounding (a conditioned room is preferred) for best operational performance and measurement results.
The apparatus should be well accessible from the operating front and left side to connect/ adjust the compressed air (accessible for maintenance; remove condensate). In case of multiple instruments they can be placed best side by side with the computer in the middle. Adjust the table surface height and levelness with a level by turning the footrests.

3.3 Preparation (unpacking, etc.)

Remove all packaging materials, check for completeness and damages and report irregularities directly to your supplier.
# 3.4 Partlist 08.67

## Compression test apparatus

<table>
<thead>
<tr>
<th>Art. no.</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>08.67</td>
<td>Soil compression test apparatus for measuring soil compression and (simultaneous) soil moisture tension with tensiometer on undisturbed Sample diam. 100 mm. Complete instrument</td>
</tr>
<tr>
<td>08.67.01</td>
<td>Compression test apparatus. Basic instrument in frame Complete with sample chamber, settlement sensor, pressure transducer and tensiometer assembly. Excl. Software</td>
</tr>
<tr>
<td>08.68.12</td>
<td>2 Sintered plate with hole</td>
</tr>
<tr>
<td>08.68.13</td>
<td>2 Sintered plate without hole</td>
</tr>
<tr>
<td>H7.00.59.5</td>
<td>Sample compression rod</td>
</tr>
<tr>
<td>H7.00.57.9</td>
<td>Sample compression stamp</td>
</tr>
<tr>
<td>08.67.10</td>
<td>Tensiometer assembly for shear test and compression test apparatus.</td>
</tr>
<tr>
<td>H2.79.80.0</td>
<td>Tensiometer filling set: 4x Syringe 10 ml 2x Filling tube with syringe tip</td>
</tr>
<tr>
<td>H7.00.59.0</td>
<td>Tensiometer container reservoir</td>
</tr>
<tr>
<td>H2.79.80.4</td>
<td>Gouge auger tool</td>
</tr>
<tr>
<td>H2.63.54.2</td>
<td>Euro Mains cable 2.5 m</td>
</tr>
<tr>
<td>H2.63.54.0</td>
<td>Mains adapter 100-250Vac 30V 1.2 A</td>
</tr>
<tr>
<td>H2.63.54.6</td>
<td>USB 2.0 screened cable</td>
</tr>
<tr>
<td>H1.04.51.0</td>
<td>Air supply hose with coupling for instrument only</td>
</tr>
<tr>
<td>H3.09.10.3</td>
<td>Mounting toolset consisting of: Tensiometer tool</td>
</tr>
<tr>
<td>99.75.06</td>
<td>Socket head wrench</td>
</tr>
<tr>
<td>99.50.14</td>
<td>Spanner 13x14</td>
</tr>
<tr>
<td>99.50.18</td>
<td>Spanner 18x19</td>
</tr>
<tr>
<td>H2.45.91.5</td>
<td>Round spirit level</td>
</tr>
<tr>
<td>H2.76.95.2</td>
<td>2x carrying rod</td>
</tr>
<tr>
<td>08.68.30</td>
<td>Basic (multifunctional) software for executing measurement protocols and visualised data presentation, english</td>
</tr>
<tr>
<td>08.67.32</td>
<td>Licence for compression test software for static multistep operation of instrument tests</td>
</tr>
</tbody>
</table>

### Optional items:

<table>
<thead>
<tr>
<th>Art. no.</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>08.68.20</td>
<td>USB HUB 4 port, incl. power supply connector UK-EC</td>
</tr>
<tr>
<td>08.67.34</td>
<td>Licence for compression test software for dynamic multistep operation of instrument tests</td>
</tr>
<tr>
<td>08.68.90</td>
<td>Calibration test set for shear test and compression test apparatus, consisting of calibrated sensors, calibration certificates, calibration blocks and spare parts. In case.</td>
</tr>
</tbody>
</table>
3.5 Partlist 08.68

Shear strength test apparatus

<table>
<thead>
<tr>
<th>Art. no.</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>08.68</td>
<td>Shear strength test apparatus for measuring soil shear strength under compression, with (simultaneous) measuring of soil tension with tensiometer on undisturbed sample. Sample diam. 100 mm. Complete instrument.</td>
</tr>
</tbody>
</table>

- 08.68.01: Shear strength test apparatus. Basic instrument in frame. Complete with sample chamber settlement sensor, transducer and tensiometer pressure assembly. Excl. software.
- 08.68.12: 2 Sintered plate with hole
- 08.68.13: 2 Sintered plate without hole
- H7.00.59.5: Sample compression rod
- H7.00.57.9: Sample compression stamp
- 08.68.10: Tensiometer assembly for shear test and compression test apparatus.
- H2.79.80.0: Tensiometer filling set:
  - 4x Syringe 10 ml
  - 2x Filling tube with syringe tip
- H2.79.80.2: Tensiometer container reservoir
- H2.79.80.4: Gouge auger tool
- H2.63.54.2: Euro Mains cable 2.5 m
- H2.63.54.0: Mains adapter 100-250 Vac 30 V 1.2 A
- H2.63.54.6: USB 2.0 screened cable
- H1.04.51.0: Air supply hose with coupling for instrument only

Mounting toolset consisting of:
- H3.09.10.3: Tensiometer tool
- 99.75.06: Socket head wrench
- 99.50.14: Spanner 13x14
- 99.50.18: Spanner 18x19
- H2.45.91.5: Round spirit level
- H7.00.67.5: Compression adapter ring
- H7.00.58.4: Sample holder upper plate
- H2.76.93.8: Sample holder fill plate
- H7.00.67.1: Sample holder lower ring
- H7.00.68.4: Sample Transfer rod
- H7.00.60.4: Sample transfer stamp
- H7.00.67.2: Sample transfer ring
- H7.00.58.7: 6 fixation pin red
- H2.76.95.2: 2x carrying rod
- 08.68.30: Basic (multifunctional) software for executing measurement protocols and visualised data presentation, english
- 08.68.32: Licence shear test software for static multistep operation of instrument tests

Optional items:
- 08.68.20: USB HUB 4 port, incl. power supply connector UK-EC
- 08.68.34: License for shear test software for dynamic multistep operation of instrument tests
- 08.68.90: Calibration test set for shear test and compression test apparatus, consisting of calibrated sensors, calibration certificates, calibration blocks and spare parts. In case.
3.6 Transport
Carefully transport and place the apparatus, although you are probably impatient to start, please take your time and precautions to prevent damage. For easy moving and transporting the transport bars can be attached. Remove the transport facilities after transport and place the black plastic profile strips.

3.7 Placement of the apparatus
Make sure that you place the apparatus in a clean, dry and not exposed to direct sunlight surrounding for best operational performance and measurement results. The apparatus should be well accessible from the operating front and in case of multiple instruments they can be placed best side by side with the computer in the middle. Adjust the table surface height and levelness with a level by turning the footrests.

3.8 Mounting the air pressure regulator
Mount the regulator to the frame and connect the black hose to the blue self locking coupling by pressing the hose firmly in and pull to test the fixation.

3.9 Connecting the air pressure
Clean, dry and stable pressured air is prescribed in the operating range of 6-7.5 bar. A pressure regulator on the instrument will restrict the pressure to the needed operating pressure of ca 7.0 bar for maximum stress load of 600 kPa or 5.599 bar for loads up to 400 kPa. Higher pressure than 7.0 bar will invoke the internal overpressure valve to operate. A stable air pressure supply is

Connect the supplied pressure hose fitted well to your pressure system and connect to the apparatus with the supplied Euro type safety connection. To connect the air supply, firmly push the self locking coupling on the connection.

The release of the air supply coupling is done in 2 steps, pullback the black ring, the air pressure then will be released and then pull further to disconnect.

⚠️ Make sure that the hoses are qualified for the pressure, fitted well and are undamaged.
Do not use air pressure below the minimum needed value to prevent wear out of the internal pressure controller.

The instrument pressure is adjusted by pulling the black knob. Turning it clockwise will increase the pressure, turning contra clockwise decreases the pressure. Push the knob down in the locked position after adjustment.

Do not exceed the maximum air pressure to prevent damage to human and apparatus. A loud noise may accompany the release of overpressure.

Lower pressure will limit the maximum applicable stress. If despite a maximum stress is programmed then the electronic air pressure controller will try to accomplish the requested value with intensive action that will reduce the lifetime of this component.

If the main supplied air-pressure is too low and the Stress settings for the apparatus are higher than can be reached at this air-pressure, the pressure regulator will make a humming noise. This should be avoided as it shortens the lifetime of this part.

If the apparatus is not in use for longer time please disconnect the air pressure.
3.10 Connecting the apparatus to the computer

Connect the USB connector to your computer. Using up to 4 apparatus use the USB hub, for up to 8 apparatus use 2 USB hubs needing 2 USB ports on your computer. The USB hubs are powered by their own mains power.

3.11 Connecting the Power supply and switch on.

Check the correct mains specifications and pug type before connecting the mains cord of the power supply to the wallet. Connect the 30 Volt output plug into the socket at the back of the instrument. The instrument can be switched on by the illuminated front push button equipped with a protective cap. The white ON indicator lamp will light up when the power is connected and the instrument is switched on. If the apparatus is not in use for longer time please disconnect the mains plug from the wallet.

Optionally, to prevent electrostatic voltages build-up introduced into the metal frame, the instrument can be connected to a protective earth terminal.
3.12 Installing the software

The software can be downloaded from the Eijkelkamp internet site; in this way you are assured to use the latest software version. For download details contact your supplier. Alternatively a CD will be supplied.

After downloading the software you run SETUP.

During installation the following menus will appear.

As the NI labview platform is used for software and hardware development you need to accept the license agreement, there are no costs or obligations involved.

After installing the main software the specific instrument files can be downloaded and installed by invoking the command “install”

After installation the program main screen will be showed and the connected instruments are recognised in the lower apparatus selection bar. The specific instrument licence and configuration files are supplied separately.
3.13  Tensiometer

The tensiometer measures the soilwatermatrix or soilwatertension inside the soil sample. The soilwatermatrix is the suction pressure of the water bounded to the soil. It is expressed in hecta Pascal (hPa). The tensiometer ceramic cup is placed in the middle of the sample chamber. It is connected by a hose to the pressure sensor that measures the soilwatermatrix both positive as negative.

The ceramic cup assembly of the tensiometer is vulnerable so do not stress it mechanically and prevent it to get greased i.e. by touching it with bare hands. Wear out ceramic cups are performing slow moisture pressure response. It is advised to check and replace it regularly.

3.13.1  Tensiometer assembly filling

Tensiometers should be filled with demineralised or distilled water. This water must be degassed. The tensiometer water limits the measuring range, as can be seen from the two-phase diagram for water and water vapour.

If the ceramic cup is completely dry, first put the ceramic cup into a beaker filled with the degassed deionised water for at least 1 hour to enable the ceramic to get saturated with water. The whole of the ceramic should be below the water level! Do not fill water into the ceramic cup as there is a danger of trapping of air in the ceramic.

If the tensiometer contains dissolved gases, the vapour point is raised, which restricts the measuring range considerably. Therefore care should be taken to degas the deionised water as completely as possible (e.g. by boiling). To degas, boil water for 5 minutes, then fill a suitable heat resistant container completely without air, seal tightly and place in refrigerator to cool.

An alternative method of de-gassing water is to heat the water to boiling, and then pull a vacuum for 15 minutes. Without heating the vacuum process takes 4 hours or more. During vacuum inductive steering or ultra-sonic stimulates the process.
3.13.2 Tensiometer installation

- Remove the tensiometer hose by loosening the coupling from the transparent body.

- Tightly grip the retraction tool into the slot of the black tensiometer body and slowly pull it out of the sample chamber.

- Put the ceramic cup into a beaker filled with the degassed deionised water for at least 1 hour.
  - Check if the water has entered the plastic transparent hose, if not the ceramic cup seems to be contaminated and must be replaced.
• Lead the plastic tensiometer hose through the sample holder and fit the tensiometer pressing it gently into the sample holder. Use a small piece of hose to protect the ceramic being touched with bare hands.
• Place the tensiometer reservoir on the cup and fill it with degassed water.

![Image](image1.png)

• Fill the tensiometer assembly using the filling syringe. Insert the small hose completely into the tensiometer hose and fill it by emptying the syringe during slowly retracting it.

![Image](image2.png)

• Fill the transparent body using the filling syringe filled with degassed water. Lead the thin hose through the valve, through the plastic body carefully into the small hole of the metal pressure transducer and empty the syringe until the water comes out of the tensiometer hose coupling.

![Image](image3.png)

• Mount the tensiometer hose by pushing the tube over the hose coupling on the transparent body and fastening the coupling by hand. Be sure to tighten it firmly but only by hand so the plastic parts will not be overstressed. (do not use a wrench)
• Connect a syringe (with the plunger fully pushed in) to the transparent body, pull the plunger out and place the wooden stick to keep in this position. Syringes can create a rather high vacuum up to -980 hPa, if the water is not that much degassed then reduce the vacuum by minor plunger pulling i.e. 1 cm.

• Now open the valve (vertical position) and allow the system for some time to retract the air out.
• The reservoir should be refilled every few minutes to prevent it from emptying and pull air into the system.
• Also repeat the syringe vacuum procedure by closing the valve, loosen and empty the syringe, connect it again, pulling vacuum and open the valve.
• If all the air is purged close the valve and the tensiometer is ready for use after checking the calibration.
• If the filling keeps still unsatisfactory, air bubbles may have formed inside the ceramic cap, then completely degas the system again.
3.13.3 Tensiometer calibration

Temperature will mainly determine the accuracy of null point of the tensiometer. So a stable environment temperature will contribute to accurate measurements. The tensiometer can be calibrated at 2 points. One can choose calibration points freely in the range of -600 hPa up to +600 hPa but advisable is to choose these points around the range of interest i.e. +10 hPa and -400 hPa.

In a well degassed tensiometer assembly apply an overpressure of 100 mm water by filling the tensiometer reservoir to the filling marker. Be sure to give the system enough time to equilibrate to the pressure.

Small zero settings can be done in the instrument configuration menu, selecting the Soilwatermatrix sensor and pressing the Calibrate sensor button. The zero-ing of the sensor will not influence the zero and scale factors. A wet tensiometer without reservoir should measure about 0 hPa and can be zero-ed.

Example:
A small offset for the tensiometer of -1 hPa is corrected to 0 hPa using the Zero Offset button.

Before and after pressing the Zero Offset button.

Be sure to press the Save button for storing the new setting on disk.
3.14 Checking and zeroing the instrument

Before measurements can be performed the instrument calibration and functionality must be checked using the software manual control option. Make sure that the sensor reading values are within calibration accuracy.

If values are not outside accuracy limits, zero calibration can be performed using the instrument calibration option. For vertical stress, soilwatermatrix, compaction and shear stress the actual value can be zero-ed at no load, using the sensitivity and scale factors. In case of problems the original factory calibration settings can be reloaded. For full sensor calibrations there is a calibration kit available or contact your supplier for calibration service.
4 Soil samples

The soil sample should be undisturbed and as the measurement quality depends on the soil sample quality care should be taken during sampling. A practical way of sampling is using the hammering method; the most precise but costly method is using hydraulic sampling equipment; this is not further discussed here.

4.1 Field sampling

- Clear and prepare the soil surface to make sure representative samples can be taken.
- Place 5 sample rings on the soil surface.
- Place the sample tool over the sample ring
- Drive the ring fully into the soil by hammering the sample tool
- Excavate the sample by spade or trowel
- Remove the surplus soil to ca 2-5 mm of the sample ring both sides
- Cover the ring with transport caps preventing to dry out and compressing the soil sample
- Register the ring number and sample details
4.2  Lab sample preparation

- Carefully remove the surplus soil on both sides of the sample ring by stepwise vertical cuttings breaking horizontal parts soil away. In this way the pore structure will kept in original condition.
- Optional weigh the sample for volumetric soil moisture content of the field capacity
- Bring the soil moisture matrix to a predetermined value of i.e. 60 hPa. (Eijkelkamp can supply the proper equipment for this)
- Weigh the sample for volumetric soil moisture content
5 Software functions

The software can be evaluated even without an instrument connected. Click the Eijkelkamp logo on your desktop to start the physical Soil Test program.

After the initialisation picture disappears, the main window will appear.

The screen is divided in 6 main parts:

1. General information
2. Options menu (pull down)
3. Protocol operation
4. Data logging (numerical)
5. Apparatus selection
6. Graphical presentations
The software supports both compression and shear test instruments, the instrument function static or dynamic are factory configured.

1 General information
   o Project name
   o Test ID
   o Start date & time
   o Operator name
   o Additional information comments

2 Options menu
   o File
     - Load session
     - Save session
     These options loads and saves the used instrument information used in this session.

   - Process file
     This option adds characters to the data files for easy recognition of events in the data file. These marked events can be used for fast relevant data sorting.

   - Exit
     - Exit ends the program and asks confirmation if this is wanted.
- **File location setup**
  In the file location setup the destination of the user data is appointed. For every operator separate subdirectories will be created automatically for both data and protocols.
- **Instrument configuration**

  Instrument configuration displays the settings of the selected instrument. The sensor settings can be changed for calibration purposes or perform sensor zeroing using the zero offset. Factory settings can be restored using the Restore Factory Defaults function.

- **Protocol configuration**

  Measurement protocols are written using predefined function tables. After the correct instrument type selection and a protocol name is defined the program steps table created using select boxes.
- **Manual Control**
  - **Actual Sensor Values**
    
The actual values of the sensor signals are displayed. Also the shear movement and vertical stress can be controlled. The applied safety stress has to be performed in
Help

- Show help
  Displays the user manual.

- About
  Information about the software version

3 Protocol operation

- Protocol file name
  The name of the protocol file that is executed

- Protocol operation
  Executing commands for measuring protocol
  A measuring protocol can be started, paused, stopped, skip a protocol step or add a comment to the data file.

4 Numerical Data logging

- Numerical presentation of logged data
  The numerical data can be observed during measurements, looking in the previous displayed values the upper right check box auto update is disabled and using the right hand slide ruler the data can be scrolled.

5 Apparatus selection

- Selection of instrument 1 up to 8 including instrument status.
  Click on the bottom bar to select the instrument of interest. The right most button displays all the instruments graphs on one screen.
6 Graphical data

- **Graphical presentation of actual and logged data and zoom functions**
  Double clicking when the mouse pointer is on the graph will invoke the zoom screen. The left-up pop-op zoom option menu enables the different zoom functions on the part of interest. Double-click on the zoom screen enables the auto full scale zoom option. Graph scales can be user edited clicking the full scale number and editing it.

- **Graphical overview presentation of all instruments**
### 5.1 Measurement protocols

All measurement steps can be programmed by means of protocols. A protocol file is written using the measurement protocol configuration option. User written or modified protocols are stored into the user directory name which is automatically generated upon entering the operator name.

- **New**
  - Starting a new file for saving the measurement protocol steps
- **Open**
  - Opening an existing protocol file for execution or editing
- **Save**
  - Saving a protocol file with his specific name
- **Save & Execute**
  - Saves and starts executing the protocol file on the instrument
- **Cancel**
  - Discards the changes and returns to the main window

To program a protocol you can choose the kind of apparatus the program will be written for. Be sure to select the right apparatus as the options differ per apparatus. Only a protocol file written for the specific type instrument can be executed. The functionality of protocol steps and step conditions are specific for each type of instrument.

Available apparatus are:
- Compression (static)
- Dynamic compression
- Shear (static)
- Dynamic shear
For static compression and static shear basic commands (cycle steps) are available, handling general measuring protocols.

The dynamic compression and dynamic shear instruments can use more sophisticated functions as cycle step loops and advanced conditional cycle steps.

All protocol steps use the same step structure:

<table>
<thead>
<tr>
<th>Field</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cycle ID</td>
<td>cycle step number</td>
</tr>
<tr>
<td>Cycle name</td>
<td>type of cycle step command</td>
</tr>
<tr>
<td>Log rate</td>
<td>data logging interval on file</td>
</tr>
<tr>
<td>Cycle Time</td>
<td>Time for the cycle step to perform its action</td>
</tr>
<tr>
<td>Stress</td>
<td>vertical stress on the soil sample</td>
</tr>
<tr>
<td>Speed</td>
<td>shear speed, only for shear instruments</td>
</tr>
<tr>
<td>Stop trigger</td>
<td>stop condition to end the cycle step time in case of trigger event</td>
</tr>
<tr>
<td>Stop condition</td>
<td>the parameter value or text used by the trigger condition</td>
</tr>
</tbody>
</table>
5.2 Program steps for the Compression apparatus

- **Static compression**
  Vertical stress will be applied to the soil sample during a specified time or one of the predefined conditions: Stop condition is based on the time specified.

- **Message**
  Display a message in a box during a specified time.

- **Wait on operator input**
  Displays a message and wait until the operators acknowledges the message with the OK button.
5.3 Program steps for the dynamic load Compression apparatus

- **Static compression**
  Stress the soil sample during a specified time or one of the predefined conditions:
  Stop conditions can be
  - **Stress**
    Compression until a specific stress value is reached.
  - **Settlement**
    Compression until a specific settlement value is reached.
  - **Moisture (absolute value)**
    Compression until a specific moisture value is reached.
  - **Moisture (down slope and value)**
    Normally a shear process waits using this condition for the soil moisture tension is reducing and below 0 hPa. This prevents faulty measurements due the ‘waterskiing’ effect.
  - **Moisture (up slope and value)**
    Shear process waits using this condition for the soil moisture tension is increasing and above the specified soil moisture value in hPa. The conditions are defined as the change of 0.4 hPa in a time period of 5 seconds; these values can be manual edited in the config.ini file.
  - **Shear stress**
    This can be used driving the motor forward up to a position where shearing forces reaches the specified value.

All stop conditions can be addressed to end the current program step or to end the loop. Therefore conditions will be marked with a letter S (Step end) or L (loop end)

- **Message**
  Display a message in a box during a specified time.
- **Wait on operator input**
  Display a message and wait until the operator acknowledge the message with the OK button.
- **Start loop**  
Starting a number of program steps that are repeated for the number of loops specified or until the stop condition of one of the program lines is reached. More then 1 loop can be used sequential but no loop in loop (recursive loops) are allowed.

- **End Loop**  
Ending the program-step loop after the stop condition is fulfilled by number of loops or individual program line stop condition.
5.4 Example Shear protocol

Explanation of the ‘shear test’ example message to operator ‘place lever in position OPERATE’
start compressing at 400 kPa during 1 hour or until the soil moisture is negative and declining
shear the motor forward with a speed of 1 mm/min during 3 minutes (3 mm) or until the shear force exceeds the 5 kPa (shear process starts), maintaining the vertical stress at 400 kPa
shear at 0.2 mm/min during 1 minutes with a log interval of 0.2 sec, maintaining the vertical stress at 400 kPa
shear at 0.2 mm/min during 4 minutes with a log interval of 2 sec, maintaining the vertical stress at 400 kPa
shear at 0.2 mm/min during 25 minutes with a log interval of 10 sec, maintaining the vertical stress at 400 kPa
shear at 0.2 mm/min during 60 minutes with a log interval of 60 sec, maintaining the vertical stress at 400 kPa
shear back at full speed for 15 minutes (30 mm) to start position

Example program Shear test instrument
5.5 Program steps for the Shear apparatus

(Per protocol step both cycle time and log interval are programmable.)

- **Static compression**
  Vertical stress will be applied the soil sample during a specified time or one of the predefined conditions:
  Stop conditions can be:
  - **Stress**
    Compression until a specific stress value is reached.
  - **Settlement**
    Compression until a specific settlement value is reached.
  - **Moisture (absolute value)**
    Compression until a specific moisture value is reached.
  - **Moisture (down slope and value)**
    Normally a shear process waits using this condition for the soil moisture tension is reducing and below 0 hPa. This prevents faulty measurements due the ‘waterskiing’ effect.
  - **Moisture (up slope and value)**
    Shear process waits using this condition for the soil moisture tension is increasing and above the specified soil moisture value in hPa. The conditions are defined as the change of 0.4 hPa in a time period of 5 seconds, these values can be manual edited in the config.ini file.
  - **Shear stress**
    This can be used to drive the motor forward to a position where shearing forces reach the specified value.

- **Message**
  Display a message in a box during a specified time

- **Wait on operator input**
  Display a message and wait until the operator acknowledges the message with the OK button.

- **Shear on time**
  Shear the sample during a specified time only or until the end position is reached. At the normal shear speed of 0.2mm/min the shear process will take 100 minutes, (1:40hour)

- **Shear on time and operator input**
  Shear the sample during a specified time or stopped before by the operator

- **Shear on time or stop condition**
  Shear the sample during a specified time or one of the predefined conditions:
  Stop conditions can be:
  - **Stress**
    Shear until a specific stress value is reached.
  - **Settlement**
    Shear until a specific settlement value is reached.
- **Moisture (absolute value)**
  Shear until a specific moisture value is reached.

- **Moisture (down slope and value)**
  Shear process stops for the soil moisture tension is decreasing and below the specified soil moisture value in hPa. The conditions are defined as the change of 0.4 hPa in a time period of 5 seconds, these values can be manual edited in the config.ini file.

- **Moisture (up slope and value)**
  Shear process stops for the soil moisture tension is increasing and above the specified soil moisture value in hPa. The conditions are defined as the change of 0.4 hPa in a time period of 5 seconds, these values can be manual edited in the config.ini file.

- **Shear stress**
  This can be used to drive the motor (fast) forward to the stage position where the shearing process begins.

- **Shear back at full speed**
  Driving at 2 mm/min the motor will be sheared back until the specified time or the end switch of the motor that disables this movement. Typically the shear back time is 15 minutes.
5.6 Program steps for the dynamic load Shear apparatus
(extra steps in addition of the standard version)
These options makes it possible to perform all actions for the dynamic compression apparatus tests.

- **Start loop**
  Starting a number of program steps being repeated for the number of loops specified or until the stop condition of one of the program lines is reached. More then 1 loop can be used sequential but no loop in loop (recursive loops) are allowed.

- **End Loop**
  Ending the program-step loop after the stop condition is fulfilled by number of loops or individual program line stop condition.
6 Measuring procedure compression test

In prior, switch on the instrument, apply the proper air pressure and start the program PST. Check the proper functioning using the manual control option

1 Empty the tensiometer reservoir by sucking it with a syringe with a short hose.
2 Remove the tensiometer reservoir with a rotating motion.

3 Place the sintered plate with the tensiometer spare hole on the sample chamber. Optional place a high flow filtration paper with tensiometer spare hole preventing smearing of the sintered plates.

4 Turn the soil sample with blunt side of sample ring for tensiometer hole preparation.

5 Make a spare hole in the soil sample for the tensiometer using the gouge auger tool to make sure that the tensiometer will fit precise as possible.
6 Place the soil sample with the tensiometer hole downwards on the sample holder.

7 Place the upper sintered plate optional using filtration paper and the sample stamp. During long tests cover the sample with a foil to prevent drying out the sample due to evaporation.

8 Lift the height sensor and place the rod and centre them carefully.
9 Close the safety cover.
10 Place the handle in position OPERATE
11 Press the yellow RESET button.

12 Start the measurement protocol pressing the software START button

**During the measurement protocol the measurements can be stopped, paused, skip the executed cycle or add a comment to the logfile.**

13 Take out the soil sample by placing the handle in UP position.
14 Clear the sample chamber and tensiometer carefully i.e. using a vacuum cleaner and a soft brush.

15 Replace the tensiometer reservoir on the tensiometer cup and refill the reservoir with degassed demineralised water to prevent it of drying out.
7 Measuring procedure Shear test

In prior, switch on the instrument, apply the proper air pressure and start the program PST. Check the proper functioning using the manual control option.

1. Place the traverse in the backwards position for optimal accessibility of the sample chamber.
2. Empty the tensiometer reservoir by sucking it with a syringe with a short hose.
3. Remove the tensiometer reservoir with a rotating motion.

4. Turn the soil sample with blunt side of sample ring for tensiometer hole preparation.
5. Make a spare hole in the soil sample for the tensiometer using the gouge tool to make sure that the tensiometer will fit precise as possible.

6. Place the lower shear ring into the sample chamber.
7. Place the sintered plate with the tensiometer spare hole in the sample chamber. Optional place a high flow filtration paper with tensiometer spare hole preventing smearing of the sintered plates.
8. Place the upper part of the sample chamber positioning it with the red fixation pins.
9. Place the transfer ring for precise transfer of the sample into the sample chamber.
10 Place the sample with the tensiometer hole downwards on the transfer ring. Place the upper sintered plate optional using filtration paper.

11 Place the sample transfer stamp (thick) and the rod (short) and centre it carefully.
12 The sample can be transferred from sample ring to sample chamber pushing it gently by hand with minimal compression until completely transferred. Alternatively one can use the manual control using the software and the handle in position OPERATE or even write an automatic transfer protocol.

13 Remove the empty sample ring and the transfer ring.
15 Place the sample holder fillplate. Lift the height sensor and place the sample transfer stamp (thin) and the sample transfer rod (long) and centre them carefully.

14 Place the traverse in the centre position using the red fixation pins.

⚠️

15 Remove the red fixation pins!
17 Close the safety cover.
16 Place the handle in position OPERATE
18 Press the yellow RESET button.

19 Start the measurement protocol pressing the software START button

During the measurement protocol the measurements can be stopped, paused, skip the executed cycle or add a comment to the logfile.
20 Take out the soil sample by placing the handle in UP position and shifting the traverse in backwards position.
21 Clear the sample chamber and tensiometer carefully i.e. using a vacuum cleaner and a soft brush.

22 Replace the tensiometer reservoir on the tensiometer cup and refill the reservoir with degassed demineralised water to prevent it of drying out.
Preface.
Soil formation including aggregate development involves changes in both physical and mechanical properties, and therefore, requires the exact definition of the limits within which properties are quantified. This is true, because in situ soil formation processes have to be linked to internal and external conditions (climatic, mechanical, thermal, hydrological, or chemical aspects) for a particular situation. Thus, all properties such as soil strength, stress attenuation, changes in soil structure or pore distribution, water fluxes, gas exchange are material functions with well-defined and quantified limits. Consequently, in order to deal with soil properties, stress, strain and strength definitions are initially required to later define the limits of the material functions with respect to the application of external stresses.

Definitions:
**Force** applied to a soil-per-unit area is defined as stress.**Stresses** working along the surface will also induce stresses in the soil, which may result in a three-dimensional deformation of the soil volume or will be transmitted as a rigid body. The mechanical behavior of a soil (volume change and shear strength) can be described in terms of the soil stress state. The number of stress state variables required to define the stress state depends primarily upon the number of phases involved. The effective stress $\sigma'$ can be defined as a stress variable for saturated conditions and is the difference between the total ($\sigma$) and the neutral stress ($u_w$) which is equal to the pore water pressure:

$$
\sigma' = \sigma - u_w
$$

where $\sigma'$ is transmitted by solid and ($u_w$) by the liquid phase, respectively. In unsaturated soils stresses are transmitted by the solid, liquid and gaseous phases. Thus, Equation [3.1] becomes:

$$
\sigma' = (\sigma - u_a) + X(u_a - u_w)
$$

where $u_a$ and $u_w$ are pore air and water pressures, respectively, and $X$ is a factor which depends on the degree of saturation. At saturation ($u_w = 0$), $X = 1$, while at $u_w = -10^4$ kPa, $X = 0$.

**Compression** refers to a process that describes the increase in soil mass-per-unit volume (increase in bulk density) under an externally applied load or under changes of internal pore water pressure. Examples of externally applied static or dynamic loads are vibration, rolling, trampling, etc. while internal forces-per-unit area include such factors as pore water pressure or suction caused by a hydraulic gradient.

In saturated soils, compression is called consolidation, while in unsaturated soils, it is called compaction. Consolidation, therefore, depends on the drainage of excess soil water determined by hydraulic conductivity and gradient. However, during compaction, less compressible air will be expelled as a function of air permeability, pore continuity and water saturation in the profile. Consolidation tests are, mainly used in civil engineering (e.g., road construction).

**Soil compressibility** described by the shape of the stress strain curve is defined as a resistance to a volume decrease, when the soil is subjected to a mechanical load. Compaction tests are used both for laboratory and for field soil compression characterizations.

In laboratory compaction, the optimum diameter to height ratio of the test cylinder should be 3-5 in order to minimize the effect of friction between cylinder wall and sample. Compaction tests to determine soil strength can be carried out on homogenized, undisturbed or bulk soil samples or single aggregate samples at different pore water pressure (i.e. water suction).

**Compactability** is the difference between the initial and maximum densities to which a soil can be compacted by a given amount of energy at defined water content.
Measurements of Soil Strength
The determination of soil strength parameters requires measurements under well-defined laboratory conditions.

Uniaxial Compression Test
The uniaxial compression test is used to define the pressure at which soil begins to fail at a given water content. A vertical normal stress \( \sigma_1 \) is applied to the soil sample, while the stresses on the planes mutually perpendicular to the \( \sigma_1 \) direction \( \sigma_2 = \sigma_3 \) are zero. The uniaxial compression test is often used to determine the tensile strength of single aggregates (crushing test).

Confined Compression Test
Soil stress-strain relationships of undisturbed structured and homogenized soils with respect to volume change are quantified in confined compression test (oedometer tests). In contrast to uniaxial compression tests, stresses in the \( \sigma_2 \) and \( \sigma_3 \) direction are undefined (rigid wall of the soil cylinder). Both time and load dependent changes in soil deformation are measured (recorded as settlement). The slopes in a void ratio \( e \) versus log \( \sigma \)-plot of the virgin compression line and the re-compression line are referred to as the compression index \( C_c = -\frac{\Delta e}{\log \Delta \sigma} \) and swelling index \( C_s = -\frac{\Delta e}{\log \Delta \sigma} \). The transition from the region of over-consolidation (re-compression) to normal consolidation (virgin compression) is defined by the pre-compression stress which separates the stress range where soil deformation is considered fully elastic (i.e. reversible) from the stress range where soil deformation is elasto-plastic (i.e. partly irreversible).

The precompression stress is defined as the stress value at the intersection of the less steep recompression curve and the virgin compression line. The latter straight line portion has a steeper slope if plotted on a semilog scale. Many methods are available to determine the precompression stress but that of Casagrande is most frequently used. Generally, the stress strain tests can be performed under 3 different boundary conditions:

A) In the consolidated drained test (CD), the soil sample is equilibrated with the mean normal stresses prior to an increase in the vertical stress \( \sigma_1 \); the pore water drains off when the decrease in volume exceeds the air-filled pore space. Therefore, the applied stresses are assumed to be transmitted as effective stresses via the solid phase.

B) In the consolidated undrained test (CU), pore water cannot be drained off the soil as vertical stress increases. Thus, high hydraulic gradients occur and the pore water reacts as a lubricant with a low surface tension. Thus, in the CU test, shear parameters are much smaller and pore water pressure values are much greater than those in the CD test.

C) The highest neutral stresses and, therefore, the lowest soil strength is measured in the unconsolidated undrained test (UU), where neither the effective nor the neutral stresses are equilibrated with the applied stress at the beginning of the test.
Figure shows the stress strain device which enables the testing and quantification of the internal soil strength, the stress induced height changes which also affect the hydraulic and pneumatic soil functions.

Undisturbed or well defined homogenized soil samples within the soil cylinders will be fixed, the tensiometer at the bottom connected with the gauge and the initial pore water pressure registered. The top capping will be placed on the sample, the strain gauge linked with the capping and the data recording controlled. In dependence of the intended test procedure either the pre-equilibration of the soil samples will be waited in order to get a defined pore water pressure controlled stress strain experiment or the stresses will be applied immediately.

The stress application and the induced strain (height and pore water pressure changes will be recorded with a frequency which can be defined according to the specific research experiments in between $x$/min to $y$/min.)

A typical graph of the experiment

The time steps as well as the normal stresses applied can be varied according to the specific requirements of the experiments between $x$-minutes per stress applied within the stress range of 0-400 kPa, as well as it can be controlled either by the still occurring strain at a given stress applied or the allowed pore water pressure variations defined by the posed research question.

The analysis of the stress strain and stress change in pore water pressure behavior can result in the determination of the precompression stress, the determination of the effective stresses, soil resilience (related to the height gain after stress release), compression index $Cc$ (= slope of the virgin compression line). (for more detailed information see the attached literature)
Shear strength parameters

The shear strength parameters cohesion (c) angle of internal friction (φ) describe the relation between the normal stress applied and the shear resistance which can be mobilized against any kind of deformation or strain and are defined according to the Mohr Coulomb equation:

\[ \tau = \tan \phi n + c. \]

3 different tests (uniaxial compression test, triaxial test, and direct shear test) can be carried out to obtain the shear parameters which according to the boundary conditions give more or less precise and defined results. The uniaxial compression test only informs about the cohesion, while the triaxial test is the most defined but also most time consuming and expensive one, which leads to only very seldom application of this test approach. Thus, primarily results of the direct shear test are presented in the literature and may be also compared with only rarely used triaxial test results.

This direct shear test is carried out under confined conditions: i.e. type and direction of the shear plane, which is assumed to be affected only by normal and shear stresses, are fixed. Normal stress is applied to the specimen in the vertical and shear stress in the horizontal direction (see figure). Compared with the confined compression device also the direct shear machine allows to analyze the time, shear speed and pore water pressure dependency during the tests.

Measurement procedure:

To determine the Mohr-Coulomb failure line at least 4-5 samples need to be tested each with a different normal stress. The maximum shear resistance (\( \tau_{\text{max}} \)) is determined from a shear stress-displacement curve and plotted against the corresponding normal stress (\( \sigma_n \)). Plotting all pairs of \( \tau_{\text{max}} \) versus \( \sigma_n \) gives the Mohr-Coulomb failure line in which the slope and intercept are the angle of internal friction (\( \phi \)) and cohesion (c), respectively. Soil stability against shear or tensile stresses is related to strength distribution in failure zones (Fig. 2). As it is true for the confined compression test device also the direct shear test can be carried out under well pre-compressed and completely drained (CD), or as consolidated undrained (CU) or as uncompressed and undrained (UU) conditions and can be furthermore affected by the shear speed and time of preloading. Thus, the boundary conditions can be defined very flexible according to the posed experimental questions.
Schematic diagram of shear strain curves and the derivation of the Mohr Coulomb failure line

Discussion of data:

In principle, soil structure will be stable if the applied stress is smaller than the strength of the failure zone, i.e., if the bond strength at the points of contact exceeds the shear or tensile stresses generated by external loads. If the resisting forces are smaller than the active forces stresses are in disequilibrium and hence soil deformation will occur to generate more contact points until stress equilibrium is reached again. Reorientation of particles is accompanied by a change of soil structure and consequently functions. In extreme stress situations (especially high shear stresses) or when soil is subject to mechanical loads in unfavorable moisture conditions (near the liquid limit) soil structure may be almost completely returned to an immature state (homogeneous soil). In contrast to shear stresses that lead to volume constant deformation, normal stresses result in volume change, i.e. compression which is plastic as soon as the soils stability is exceeded. In situ stress conditions during field operations (traffic, soil-tool interactions) are generally characterized by a combination of both shear and compressive stresses. For comparable grain size distribution, bulk density and pore water pressure, soil strength increases with aggregation (i.e., coherent < prismatic < blocky < subangular blocky < crumbly). In the case of a platy structure the strength depends on the direction of shear forces relative to the preferred orientation of the particles. In the direction of the elongated axes of aligned particles shear strength is lower than perpendicular to it.
Literature

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Eijkelkamp expresses thanks to the scientific contributions of Prof. R. Horn and J. Rostek
Appendix 2  Maintenance & service

Problem solving, tips and tricks
Q  The software screen is not completely covering my monitor screen
A  The screen resolution is fixed for compatibility reasons, full screen coverage can be obtained only by adjusting the screen resolution in Windows.

Q  The instrument makes an internal sissing sound
A  Check for the input air pressure, the maximum is 7 Bar and possibly the overpressure safety regulator is venting. Reduce the input pressure

Q  The system makes a ticking noise and the maximum stress is not available.
A  Make sure that the handle is in position operate, check for input pressure on the pressure regulator.
   •  Check handle for position Operate
   •  Check safety cap in position
   •  Check pressing the yellow reset button after opening the safety cap
   •  Check air pressure supply

Q  Message safety monitor failure
A  The measured force is not within expected limits invoking a safety procedure:
   •  Check handle for position Operate
   •  Check safety cap in position
   •  Check pressing the yellow reset button after opening the safety cap
   •  Check air pressure supply

Press OK for removal of the message, clear the problem and restart the test

Q  The maximum stress is not available.
A  check for input air pressure on the pressure regulator.
Q An instrument is not responding, indicating a red instrument selection button.
A Remove the instrument USB cable on the computer, if the error message appears confirm the OK button and reconnect the USB cable.

Q An instrument is not responding, due to disturbed internal electronic controller
A Check in manual control for analog values Remove the instrument USB cable on the computer, if the error message appears confirm the OK button then reconnect the USB cable.

Q The tensiometer is reacting slow.
A Check for air in the system, refill it. If it does not fix the problem replace the tensiometer assembly.
**Calibration Maintenance and Service**

Before measurements can be performed the instrument calibration must be checked by the Manual control option and in case of inaccuracy performed using the Configuration, option instrument configuration. By clicking the channel and calibrate sensor the individual calibration screens become available. If the calibration is unsuccessful the last known calibration can be restored.

Often only tensiometer and force sensors need justification in offset, this can be done in

It is strongly advised to copy the factory calibration for backup purposes.

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**Service interval schema**

This interval schema based on regular use and are only as indication. Based on local conditions and experience the intervals can be altered.

- Sensors offset 1 week
- Remove condensate from air filters and compressor 1 month
- Ultrasonic cleaning sintered plates 3 months
- Calibration check 3 months
- Recalibration 1 year
- Ceramic assembly replacement 1 year
- Air filter check 1 year
- General maintenance** 3 years
  - Specifications check
  - Functionality check
  - Wear-out check, mechanical, pneumatic incl hoses, electric
  - Recalibration against traceable standards
  - Repair

**Please consult Eijkelkamp for service contract proposals**
Appendix 3  Software file structure

Program system files
The main program is located at drive C: Program Files\Eijkelkamp\Physical Soil Test, PST.exe
The User data is located at C:\soil Test Data
Other user specified location can be selected during installation of the software or using the menu Configuration, option File location setup

C:
    Program Files
        Eijkelkamp
            Physical Soil Test (executable PST.exe)
            Data (program specific files)
            Help (user manual files pdf format)
Program configuration files

Only the DATA Username files containing measurement result data in CSV format are of primary interest to the user. All configuration and protocol files are stored in text format, it is not recommended to edit these files by hand as the program user interface helps to prevent typing or other mistakes.

C:
  Soil Test Data
    Configuration
      • Configuration (general settings file)
      • Hoogte_correctie_instrumentx (instrument specific calibration file)
      • Instrumentx (instrument specific calibration file)
Program data files

C:
- Soil Test Data
  - Data
    - Default
    - Username1 (data result files CSV format User1)
    - Username2 (data result files CSV format User2)
  - Protocols
    - Default (common protocol files All Users)
    - Username1 (protocol files User1)
    - Username2 (protocol files User2)
### Data file format

The data files can be read into general spreadsheet programs. The file naming is based on instrument, date and time.
## Appendix 4 Conversion table Newton to kPa

Based on 98 mm diameter sintered plates.

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<th>N</th>
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<th>kPa</th>
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<td>790 51.6</td>
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<td>980 65.9</td>
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<td>0.5</td>
<td>2850 174.1</td>
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<td>0.7</td>
<td>3070 196.0</td>
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<td>11850 738.0</td>
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<td>31750 2120.0</td>
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<td>60200 3683.0</td>
<td>10</td>
<td>63000 3960.0</td>
</tr>
</tbody>
</table>
Appendix 5  CE declaration of conformity

The undersigned, representing the manufacturer:

Eijkelkamp Agrisearch Equipment BV
Nijverheidstraat 30
6987 EM Giesbeek
The Netherlands

Herewith declare that the products:

**Type:**  Compression Test Apparatus
Art.nr.: 08.67
Function: Measuring soil compression strength and simultaneous measuring of soil suction and displacement

And

**Type:**  Shear Strength Test Apparatus
Art.nr.: 08.68
Function: Measuring soil shear strength under compression and simultaneous measuring of soil suction and displacement

is in conformity with the essential requirements of the following EC Directive(s) when installed in accordance with the installation instructions contained in the product documentation:

- 2006/42/EC Machinery Directive
- 2004/108/EC EMC Directive
- 2002/96/EC Waste Electrical and Electronic Equipment (WEEE)
- 2002/95/EC RoHS Directive

and that the standards and/or technical specifications referenced below have been applied:

- NEN-EN-ISO12100-1: 2003 Safety of machinery – Basic concepts, general principles for design – Part 1&2
- EN 61000-6-1- Generic immunity standard
- EN 61000-6-2- Generic emission standard

Giesbeek, 1-August-2010

Manufacturer:

**Signature**

Fons Eijsink
General Manager